DISCUSSION

ALFRED EDWARD GALLANT, M.D. (727 West Seventh Street, Los Angeles).—Doctor McCuskey's paper offers a very interesting phase of anesthesia for orthopedic operations, and a practical application of what he has stated and outlined is of much value because it allows the surgeon a better facility for performing his work. It has been found that regional anesthesia minimizes the possibility of shock, especially in those cases which are bad risks. In the past four years we have employed this method in about thirty cases in which Doctor McCuskey provided the anesthesia technique. To cite a few of these cases, a woman who had both bones of the left forearm fractured and a fracture of the left patella, regional anesthesia was given, under brachial block for the correction of the forearm fractures, and a femoral block for the patella fracture. There had been a head injury in this case, and I am of the opinion that an ether anesthesia would not have been a satisfactory method. The use of the regional blocks proved to be of much advantage. A second instance, a man with a spiral fracture of the humerus, brachial block was employed. This man had been a heavy drinker, and it was certain that recumbency, if the Bardenhauer method had been employed, would not have been satisfactory. The regional block allowed us to apply a shoulder spica and the patient became ambulatory. Another instance of a comminuted spiral fracture of the right humerus in a young woman where a head injury had also existed, made a satisfactory handling of the case a relatively simple procedure. A spiral fracture of the shaft of the humerus in a woman over eighty years of age was satisfactorily reduced. Patient was allowed to become ambulatory, and much more comfortable than in cases where there were recumbency and extension. Another instance, a man of eighty-four years of age with fractures of both tibiae, and right humerus, involving the elbow joint, a very bad risk and treated with regional anesthesia, resulted in satisfactory reduction and outcome. Therefore, I am of the opinion that regional anesthesia will gradually become more universally used because of its possibilities in orthopedic problems.

HUGH JONES, M.D. (201 Medical Office Building, Los Angeles).—More extensive use of regional anesthesia in orthopedic operations will probably come about as anesthetists perfect the technique to the point where the surgeon and patient can confidently expect a painless operative procedure. The surgeon himself may be able to acquire this skill; but in general it is better to trust this work to an anesthetist whose experience is such that satisfactory anesthesia can be counted upon regularly.

The cervical plexus block for manipulating fractures of the cervical spine has been very comforting to me, because I have felt very uneasy about assuming the responsibility in such a case, with the weight of the head and relaxed neck as it hangs with the helpless patient under general anesthesia.

The brachial plexus block has been very helpful, indeed, for time-consuming tendon and nerve repair. A particular advantage is usually found in the ability of the patient to contract the various muscles, and this helps in the identification of the different tendons. This voluntary control is also appreciated when it is possible to try out the return of function before closing the wound. Leaving the needle in place to reinforce waning anesthesia, is an advantage easily appreciated.

More frequent use of paravertebral anesthesia should be made in the Hibbs and Albee operations, as well as for laminectomy. For the Albee operation, the leg can well be anesthetized by surrounding the operative site for the removal of the graft from the shin.

In emergency work one feels much safer about a patient with a full stomach, if the dangers incident to vomiting while under the anesthetic can be avoided. Local anesthesia provides this factor of safety.

COMPENSATORY PRESSURE IN ANESTHESIA FOR THORACIC SURGERY*

By W. LAWRENCE, M.D.
San Francisco

DISCUSSION *by William Neff, M.D., San Francisco; G. D. Delprat, M.D., San Francisco.*

OCCASIONALLY, during the task of administering an anesthetic one is confronted by a sudden crisis which threatens the safety of the patient, disturbs the surgeon, and chills the spine of the anesthetist. At a time such as this it is essential to analyze the situation promptly and to institute the proper corrective measures. This is especially true when seemingly indicated readjustments in the anesthetic fail to produce the desired result.

Such a sudden crisis may occur during operations upon the thorax which necessitate the opening of a hole of any considerable size in the chest wall. The following is somewhat the order of the train of events as they take place:

A patient under nitrous oxid anesthesia, reinforced by local infiltration, chloroform, cyclopropane or intravenous barbiturates, may be breathing quite evenly and showing no signs of either anoxemia or overdosage of anesthesia. When the thorax is opened, however, the respiratory rate increases, the depth of breathing increases, the pulse rate and pulse volume increase and cyanosis appears. An increase of the oxygen flow to the patient is the first consideration, and is promptly provided. The desired evidence of oxygenation does not result. Cyanosis becomes deeper and asphyxial spasm begins to manifest itself. The pulse becomes more rapid and more feeble. The pupils dilate and the skin becomes mottled. Suddenly, just at the moment when oxygen in the lungs is of the utmost importance, the anesthetist is confronted with the most distressing of all conditions in inhalation anesthesia, *i. e.*, spasm of the glottis and of the respiratory muscles. That death does not more often supervene is undoubtedly due to the fact that, after the fatigue of the prolonged asphyxial spasm, a sufficient relaxation of the glottis occurs to permit the anesthetist to force a small amount of oxygen into the lungs under pressure, and the patient revives with evidence of considerable shock. The abruptness with which the foregoing disturbance breaks into the course of the anesthesia is probably the reason why deaths at this point have been variously ascribed to embolism, acute dilatation of the heart, shock, collapse of the trachea, or status lymphaticus.

Convinced that the foregoing syndrome was, in most cases, due entirely to oxygen-want carried to the stage of asphyxia, I began to use increased pressure in the breathing bag promptly at the time the chest wall was opened, or when its rigid structure was disturbed by a resection of the ribs. The result of maintaining pressure during this period of the operation is so gratifying that I feel the subject is worthy of emphasis before this group.

* Read before the Anesthesiology Section of the California Medical Association at the sixty-sixth annual session, Del Monte, May 2-6, 1937.

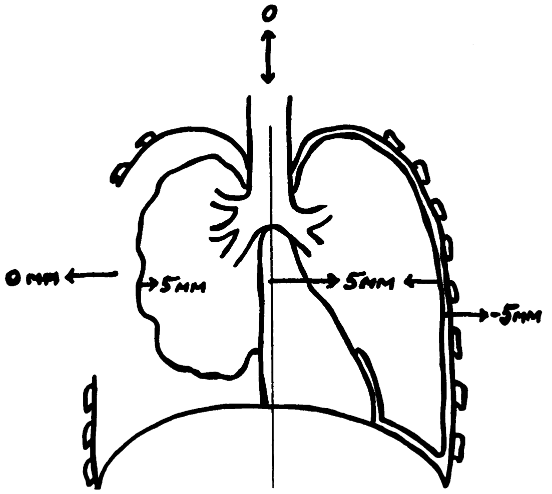

Fig. 1

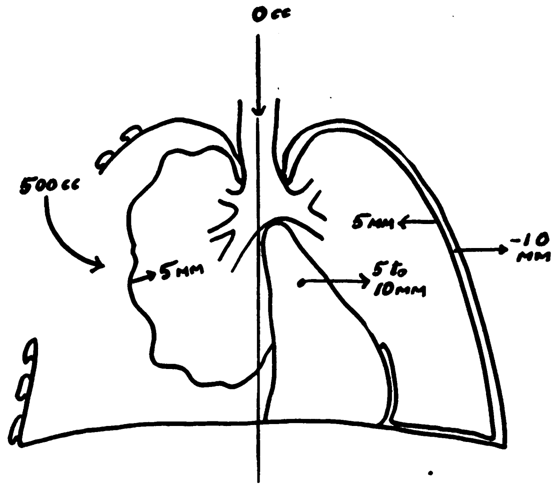

Fig. 2

Fig. 1.—Illustrating status of intrathoracic pressures during rest—right thoracic wall open. Intrapulmonary pressure 0.

Fig. 2.—Illustrating ineffectiveness of inspiratory effort when thorax is open. Intrapulmonary pressure 0. Note mediastinal displacement.

NORMAL ANATOMY AND PHYSICS OF INTRATHORACIC PRESSURE

When the thorax is at rest there exists in the potential pleural space a vacuum of 5 millimeters of mercury. This 5 millimeters vacuum is produced by the centripetal pull of the lungs, due to their own elasticity opposed by the semirigid structure of the rib-cage and diaphragm at the limit of relaxation. The mediastinum remains in the midline because the pull upon it is equal in both lateral directions.

Upon inspiration the intrapleural vacuum is increased to 10 millimeters of mercury, due to the enlargement of the chest cavity by the raising and expansion of the rib-cage and the downward movement of the diaphragm. The 5 millimeters centripetal contraction tendency of the lung is overcome by the 10 millimeters vacuum, and the lungs fill. The mediastinum remains balanced in the midline position.

It is pertinent to observe here that the flaccid contents of the mediastinum, and its somewhat narrow anterior and posterior attachments, make it a quite movable structure.[1] In the cadaver with normal lungs it has been observed that the mediastinum will move some three inches to the left and some two inches to the right from the normal midline position.

Another anatomical consideration to be borne in mind is that the area of the normal glottis is about 2.5 to 3.0 square centimeters.

DISTURBED INTRATHORACIC PRESSURES

Assuming that an opening of considerable size is made in the right thoracic wall, and the left remains intact, it becomes evident that the intrathoracic pressure relationships are promptly disturbed. At rest the negative pressure in the right pleural cavity is now zero and the 5-millimeter pull of the left lung displaces the mediastinum somewhat to the left. (Diagram 1.)

The physics of the failure of the respiratory system becomes evident upon consideration of a diagram of the open thorax during inspiration. (Diagram 2.) The inspiratory effort results in an ingress of air into the right pleural cavity as the thorax expands, the air taking the course of least resistance. The mediastinum is displaced further to the left by the 10 millimeters vacuum of the left pleural cavity which is now added to the 5-millimeter contracting pull of the left lung. Against these forces there is now no balancing pull in the right thorax. The mediastinal displacement thus makes the inspiratory expansion of the left thorax almost entirely ineffective, in so far as aeration of the left lung via the trachea is concerned.

Thus the quantity of air or gas entering the unoperated lung under the foregoing conditions will be in inverse ratio to the disproportion between the opening in the chest wall and the opening of the glottis, *i. e.,* if the disproportion is great the amount of air or gas entering the left lung will be small. It has been estimated that the limit of disproportion between the size of the opening in the glottis and the opening in the chest wall, which is compatible with life, is as one to twenty. In other words, if an opening is made in the chest wall having an area of more than 50 square centimeters, the patient will die within a short time of asphyxia in an ordinary atmosphere.[2]

During the expiratory phase of the respiratory cycle the mediastinal structures move to the right, and the air is emptied from the right thoracic space through the thoracotomy opening, and the status is again as described during rest.

The side-to-side movement of the mediastinum with respiration has been referred to as "mediastinal flapping," and is comparable to the vigorous movement of the slack sails of a yacht as the air pressure shifts alternately from side to side.

It becomes evident that, with an insufficient exchange of anesthetic gases having a lowered oxygen

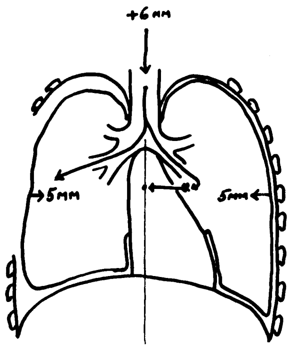

Fig. 3

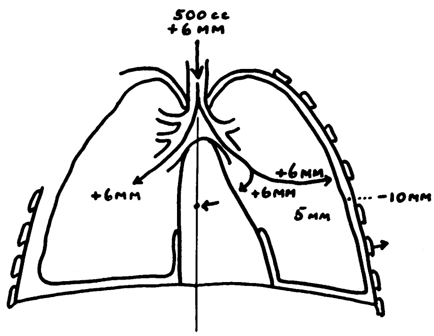

Fig. 4

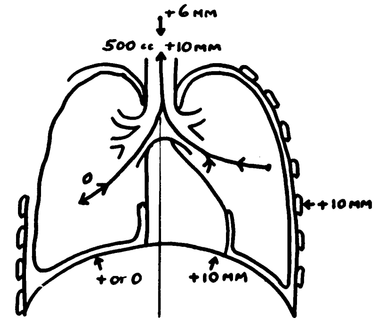

Fig. 5

Fig. 3.—Illustrating effect of increased intrapulmonary pressure during rest when thorax is open. Note indicated mediastinal stabilization.

Fig. 4.—Illustrating effect of increased intrapulmonary pressure during inspiration when thorax is open. Note indicated mediastinal stabilization.

Fig. 5.—Illustrating expiration against increased intrapulmonary pressure. Right lung remains inflated, medi astinum stabilized and the left lung emptying.

percentage, between alveoli and breathing bag the patient must of necessity very soon progress into a state of anoxemia, if a correction is not made to offset the disturbed intrathoracic pressure relations. The overactivity of the respiratory muscles, and the generalized muscle spasm which follow, cause an increased metabolic rate which still further increases the deficit between oxygen requirement and oxygen supply. Furthermore, the spasm of the glottis, which almost invariably accompanies anoxemia, also impedes the exchange of gases between lungs and breathing bag.

It is quite the natural thing for the anesthetist, having increased the oxygen flow to the patient, to be lulled into a false sense of security. This will of necessity be of brief duration because, in a matter of seconds, the patient passes through a convulsion and into a state of complete asphyxia. The pupils dilate, the skin becomes mottled, respiratory efforts cease, and the pulse becomes imperceptible. The fact will bear repeating that the unbelievably sudden climax of the syndrome makes one feel, erroneously, that the disturbance must be circulatory in nature and the etiology something akin to embolism.

The so-called "paradoxical breathing," manifested after closure of the wound, undoubtedly belongs in this classification of disturbed intrathoracic pressures. The flaccid operated side falls inward with inspiration and moves outward with expiration. The mediastinum probably exhibits the same undesirable lateral movement seen when the chest is open. I have observed rather severe anoxemia resulting from this condition at the close of thoracic operations.

FACTORS INFLUENCING DISTURBED PRESSURES

Fixation of the mediastinum by disease, thickened pleura, accommodation resulting from long-standing treatments, such as pneumothorax, pleural adhesions, and probably other more obscure factors, serve to neutralize to some extent the disturbance of intrathoracic pressures by operations.

COMPENSATORY PRESSURE

The Sauerbruch chamber was designed to create the vacuum necessary to offset the disturbance of intrathoracic pressures resulting from opening the chest wall.[3] It consists of an air-tight, steel chamber from which sufficient air may be pumped to create the desired vacuum on the inside of the chamber. The patient's body and the entire operating team are inside the chamber, and the patient's head and the anesthetist are outside. As may be readily imagined, the apparatus is cumbersome and expensive.

Since it makes no practical difference, so far as end-results are concerned, whether the difference in pressure is obtained by lowering the extrapulmonary pressure or by increasing the intrapulmonary pressure, it is certainly more feasible to employ the latter means of making the readjustment. For this purpose the Brauer high-pressure apparatus[3] was devised. It is also unnecessarily complicated.

We have been able to obtain a satisfactory stabilizing effect upon the mediastinum and aeration of the nonoperated side by maintaining a pressure just sufficient to overcome the 5 millimeters centripetal contraction tendency of the lungs. A pressure of about 6 millimeters of mercury has been quite sufficient in most cases.

The essential features of a satisfactory set-up for the successful maintenance of compensatory pressure are as follows:

1. A clear airway.
2. Air-tight connections in apparatus and between face and mask.
3. Pressure gauge in the circuit.
4. Absorber to dispose of expired carbon dioxid.
5. Accurate oxygen flow gauge.

An increased flow of oxygen and anesthetic gases may be maintained to offset small leaks in the apparatus and about the face.

With this arrangement the pressure throughout the entire system and into the patient's lungs is built up until the desired level is reached and maintained so until the thorax is closed.

During rest the pressure serves merely to hold the mediastinum in the normal midline position. (Diagram 3.) The lung on the open side, having partially collapsed, appears to withstand more pressure than we would suppose, for we have not observed dangerous overdistention at even a pressure of 7 millimeters.

The effectiveness of sustained pressure becomes most evident during inspiration. (Diagram 4.) It now serves to hold the mediastinum steady in the midline position, while it also inflates the left lung to the limits of the expanded thoracic cavity. Gases bearing fresh oxygen thus enter the left lung. The right lung remains inflated and immobile. Whatever undesirable effect there may be upon the right lung from distention must be tolerated for the time being.

During the expiratory phase of the cycle the resilience of the left thoracic wall and diaphragm, plus the 5 millimeters contracting tendency of the left lung, are sufficient to overcome the 6 millimeters positive pressure of the breathing bag, and the atmosphere of gas in the left lung is propelled back into the breathing bag through the carbon dioxid absorber. The right lung and the mediastinum are held stable in their previous positions. (Diagram 5.)

A prompt improvement in an anoxemic patient's condition will be noted immediately upon the institution of sustained compensatory pressure sufficient to overcome the centripetal contraction tendency of the lungs, and sufficient to immobilize the mediastinum.

Pressures beyond 10 to 12 millimeters of mercury will result in rupture of the alveoli, and should be avoided.

Asphyxial symptoms may also appear during local or intravenous anesthesia, although not so rapidly as when the atmosphere has been reduced to a ten per cent oxygen content, as in nitrous oxid anesthesia. I have observed the onset of asphyxia while administering continuous intravenous anesthesia for thoracoplasty, and have corrected the condition by strapping on a mask and supplying the needed compensatory pressure while continuing the injection.

There is no doubt but that the involuntary effort of breathing against pressure must of necessity exhaust the patient after a short time, and certainly the operation should be terminated with the greatest possible speed.

Although I have been using the ordinary rubber-cushioned face mask strapped to the head, occasionally intubating the trachea transnasally with McGill tubes, with much success, I feel that the method can stand considerable improvement. The following is a technique which appears to have many good features, and which I hope to give a trial in the future:

A SUGGESTED TECHNIQUE FOR COMPENSATORY PRESSURE

1. Premedication with a large, but safe, dose of some barbituric acid derivative one and one-half hours preoperatively.
2. Morphin and hyoscin forty-five minutes preoperatively.
3. Anesthetization of the pharynx and larynx with a spray.
4. Intravenous barbituric acid derivative sufficient to give good relaxation of the jaw.
5. Intubation of the trachea, with a semi-rigid tube with an inflatable cuff to seal the space between the tube and the wall of the trachea (as described by Waters).[4] Intubation of the bronchus to the good lung would probably be an advantage in cases of bronchial fistula or bronchiectasis.
6. Inhalation anesthesia with nitrous oxid reinforced by chloroform, cyclopropane, or ether.
7. Suction to evacuate pus, blood, or mucus from the accessible branches of the bronchial tree beyond the end of the endotracheal tube.
8. Compensatory pressure during the periods of disturbed intrathoracic pressure.

SUMMARY

1. Normal thoracic pressures and anatomy relating to anesthesia have been reviewed.
2. The physics and anatomy of disturbed intrathoracic pressures and the ill effects thereof have been discussed.
3. The effects and method of instituting compensatory pressure have been described.
4. A technique is suggested for handling cases for thoracic surgery.

54 Brentwood Avenue.

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2. Wright: Applied Physiology, p. 382.
3. Oxford Surgery, Vol. 4, Part 1, p. 130, Fig. 35, and p. 131, Fig. 36.
4. Gale and Waters: Closed Endobronchial Anesthesia in Thoracic Surgery, Current Researches in Anesthesia and Analgesia (Nov. and Dec.), 1932.

DISCUSSION

William Neff, M.D. (Stanford University Hospital, San Francisco).—Doctor Lawrence has given us a most interesting paper on a subject which should be the concern of every anesthesiologist. When so many drugs, both volatile and nonvolatile, and techniques, ranging from intravenous barbiturates and endobronchial or endotracheal gases to subarachnoid block, are recommended for anesthesia in intrapleural surgery, it is apparent that all have their shortcomings. Regardless, however, of the agent or the technique, there is general agreement that compensatory pressure should be used. Dr. Harry Shields, senior anesthetist to the Toronto General Hospital, and Dr. I. Magill of London are two of the outstanding anesthesiologists who advocate the use of spinal anesthesia for intrapleural surgery. They have observed that if anesthesia to the third thoracic segment is produced, circulatory shock is far greater when the abdomen is opened for gall-bladder surgery than when the pleura is opened for intrapleural surgery. These observations, emanating from such keen minds, are worthy of further study. Endobronchial anesthesia is still in the experimental stage. One must seriously consider the partially collapsed lung which is blocked, but in which the blood supply still remains. It is clinically most difficult, if not impossible, even when agents are used which permit double the atmospheric concentrations of oxygen, or increased pressure is also maintained, to prevent the symptoms of oxygen lack. Dr. E. Rovenstine of the Department of Anesthesia at Bellevue Hospital, recommends total blocking of a bronchus, not to exceed eight minutes, until the ligature has been applied. It should be remembered, also, that intubation of the left bronchus, with a thin-walled, large lumen tube is not easy.

Direct vision endotracheal intubation with a large lumen, thin-walled tube surrounded by a Waters-Guedel inflatable cushion, under inhalation anesthesia, is the method which, because of its controllability, appeals to me most. To produce adequate pressure to approach a more rigid mediastinum, the application of hand pressure to an already moderately distended breathing bag attached to a Waters (to and fro) soda-lime canister which, in turn, is connected to the endotracheal tube, is simple, safe, and efficient.

In so far as agents are concerned, one must keep in mind that, where mixtures of agents are used, the metabolic disturbances are always particular to the most toxic; so that when chloroform or ether has been used to fortify nitrous oxid, ethylene, or cyclopropane, one must think of toxicity in terms of the former group rather than the latter.

G. D. Delprat, M.D. (384 Post Street, San Francisco). Doctor Lawrence has presented very clearly the technical considerations of anesthesia on the open thorax. As is evident in his paper a clear conception of the underlying physiology on the part of the anesthetist is an absolutely necessary and fundamental prerequisite. Then follows the need of his ability to recognize the symptoms of disturbed physiology, and his prompt correction of gas concentrations and pressures. No anesthetist without this fundamental background should permit himself to undertake any chest operation anesthesia; for even should an operation be planned that does not contemplate opening the pleura, yet this possibility is ever present. Under certain circumstances, for instance, a simple rib resection for empyema in a sick individual may be very shocking if the thoracic pressure relationships are abruptly disturbed. The technical points of this subject are ably presented. No discussion of the paper, however, would be complete without reference to the art of anesthesia which all surgeons will admit is nowhere so well demonstrated as by the competent "chest anesthetist."

There is unquestionably no comfort so great to the surgeon as the knowledge that the man behind the anesthetist's screen is alert, competent and reliable. The feeling that it is not necessary to glance over the drapes at that visible portion of the patient's face, and that it is not necessary to give directions to an already harassed anesthetist, is worth untold riches. To be able to ask, "How is the patient?" and to know that the reply, "He is all right," or "He will be all right in a minute," means what it says, is as great a comfort as the reverse is a torment. While Doctor Lawrence would be the last person to admit it, I will say that he gives just such an anesthetic!

THE LURE OF MEDICAL HISTORY†

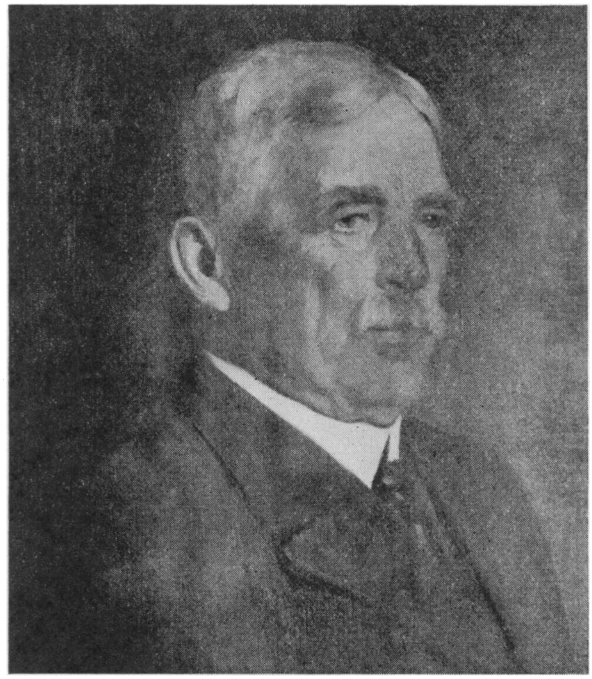
THOMAS WATERMAN HUNTINGTON A. B., M. D., LL. D.

V*

By Wallace I. Terry, M.D.
San Francisco

Doctor Huntington was born on January 16, 1849, at Rockford, Illinois, but sprang from New England stock. He was a descendant of Samuel Huntington, a prominent clergyman of Massachusetts and a signer of the Declaration of Independence. His father, Charles, was also a clergyman and an educator, and it was at his hands that the subject of our sketch received his early education. Doctor Huntington was graduated in 1871 from the University of Vermont, which institution, in 1913, also conferred on him the degree of LL.D.

As his finances were low after leaving college, he taught school and later entered Harvard Medical School, where he received his M.D. degree in 1876. At Harvard and at the Massachusetts General Hospital, where he interned, he came under the influence of such teachers as Oliver Wendell Holmes in anatomy, Porter, Warren, Homans, Bigelow, and Cheever in surgery, Fitz in pathology, and others prominent in the profession.



THOMAS W. HUNTINGTON
1849–1929

He began to practice in Nevada while it was still a frontier region, and there became a surgeon for the Central Pacific Railroad. His work in the latter capacity led to his appointment, in 1882, as assistant chief surgeon of the company hospital in Sacramento, the first hospital in the world devoted exclusively to railway employees. In 1885, he was made chief surgeon, and held that post for thirteen years, when he came to San Francisco and succeeded Robert A. MacLean as professor of clinical surgery in the University of California Medical School.

From 1882 to 1919, Doctor Huntington was quite a steady contributor to surgical literature. His papers dealt with a wide variety of topics, such as antisepsis and asepsis, surgery of the extremities, intestinal obstruction, gunshot and stab wounds of the abdomen, and pyloric stricture, for which he did Loreta's operation in 1889. He also wrote about aneurysm, appendicitis, hernia, nephrolithotomy, amputations, fractures, splenic cysts, stomach and gall-bladder surgery, and x-ray burns.

Some of his papers are important from a historical, as well as factual standpoint. As early as 1882, for example, he read a paper on "Antiseptics, as Applied to Surgical Art," from which I quote: "Without personal experience or experiment, with no ocular proof or demonstration, I have become a convert to the theory which has lent inspiration to surgery, and has ushered in a brighter era for sufferer and attendant alike." Two years later he

†A Twenty-Five Years Ago column, made up of excerpts from the official journal of the California Medical Association of twenty-five years ago, is printed in each issue of California and Western Medicine. The column is one of the regular features of the Miscellany department, and its page number will be found on the front cover.

* One of the papers given in Toland Hall, University of California Medical School, San Francisco, in the series on the history of the institution, arranged by the Division of the History of Medicine.

This is Paper V of the series. For other articles in the symposium, see California and Western Medicine, November, 1937, page 321; December, page 405; January, page 27; February, page 114.